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ROAD STANDARDS

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Section 9113

POCKET FIELD GUIDE

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9113 - ROADS

Excerpts from 9113 Manual
Section on Roads

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FOREWORD

This guidebook was prepared from excerpts of the Bureau of Land Management (BLM) 9113 Manual Section on ROADS.

Only those sections pertaining to design, design standards, and construction were excerpted to provide a quick and easy reference for users contemplating the construction, improvement, or maintenance of roads on the public lands administered by the Bureau of Land Management.

INTRODUCTION

Purpose. The purpose of this guidebook is to consolidate the Bureau of Land Management Geometric and Design Standards for roads on the public lands into a handy reference guide.

Background. The material contained in this guidebook is excerpted from the Bureau of Land Management 9113 Manual Section on Roads and does not contain all subsections contained within the 9113 Manual Section.

Applicability. This guidebook is issued for the guidance of Resource Managers, District Engineers, and other users of the public lands having responsibility for the construction, improvement, or maintenance of roads on public lands administered by the Bureau of Land Management.

.06 *Policy.* It is Bureau policy that:

A. Bureau roads must be designed to an appropriate standard no higher than necessary to accommodate their intended functions adequately, (timber hauling, administrative access, public travel); and design, construction, and maintenance activities must be consistent with national policies for safety, esthetics, protection and preservation of cultural, historic, and scenic values, and accessibility for the physically handicapped.

B. Bureau roads are for use, development, protection, and administration of public lands and resources, and, though administered by a public agency, "and generally open to use by the general public," *are not public roads.* Bureau roads are subject to rules and regulations of the Secretary of the Interior, and, although public use is generally allowed, roads may be closed or use restricted to fulfill management objectives such as protecting public health and safety or preserving resources. Bureau roads may also be subject to State and other Federal regulations as necessary to protect public health and safety. Bureau roads which no longer support a management objective (timber sale, range improvement, etc.) are obliterated and revegetated. Obliterations, closures, and use restrictions, except for emergency reasons, are identified through the Bureau Planning System.

C. Continuous coordination with other agencies and public road authorities is undertaken to assure that land use, resources, and public interests are represented and that Bureau road management actions and activities are appropriate.

D. The location, design, construction, and maintenance of roads crossing public lands must comply with all applicable Federal Laws.

E. All roads controlled by the Bureau must meet appropriate Bureau road standards, whether or not they are constructed by Bureau initiative.

F. All Bureau road designers must be qualified (see .42 for requirements) and all permanent roads constructed by non-government entities across public lands must be designed by or under the direction of a licensed professional engineer.

G. All Bureau roads must be identified with appropriate route markers and must be signed adequately for user safety. (See BLM Manual Section 9131).

H. The location, design, construction, and maintenance of roads crossing public lands must consider and protect endangered species of plants and animals on the Federal List of Endangered Species.

I. Roads crossing public lands must be located, designed, constructed, and maintained so as to protect and preserve natural, historic, cultural, and scenic values.

J. The acquisition of easements for existing roads may not be initiated until a route analysis per .31 has been completed and has determined that an existing facility is sufficient for Bureau needs or, if new construction or reconstruction is required, until an approved design has been developed to a point where the actual easement can be dimensioned. (See BLM Manual Section 2130 *et seq.* for requirements).

K. Bureau roads should be inspected both at regular intervals and immediately after events such as severe storms to determine emergency actions or priority maintenance needs. The top priority is to protect the users, reduce hazards, and prevent further deterioration of the facility.

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.16 Functional Classification. The method and terminology recommended by the National Highway Functional Classification Study of 1968 provides guidelines for classifying Bureau roads. The Bureau has added resource roads as a category in addition to those identified in the 1968 study (as recommended by an interagency tasks group study on low-volume road standards, 1976-1977). As Bureau roads are predominately low volume and are generally extensions of, or connectors to State or county systems, an "arterial" category does not apply to Bureau roads. Classify Bureau roads as follows:

A. *Collector Roads.* These Bureau roads normally provide primary access to large blocks of land, and connect with or are extensions of a public road system. Collector roads accommodate mixed traffic and serve many uses. They generally receive the highest volume of traffic of all the roads in the Bureau road system. User cost, safety, comfort, and travel time are primary road management considerations. Collector roads usually require application of the highest standards used by the Bureau. As a result, they have the potential for creating substantial environmental impacts and often require complex mitigation procedures.

B. *Local Roads.* These Bureau roads normally serve a smaller area than collectors, and connect to collectors or public road systems. Local roads receive lower volumes, carry fewer traffic types, and generally serve fewer uses. User cost, comfort, and travel time are secondary to construction and maintenance cost considerations.

Low volume local roads in mountainous terrain, where operating speed is reduced by effort of terrain, may be single lane roads with turnouts. Environmental impacts are reduced as steeper grades, sharper curves, and lower design speeds than would be permissible on collector roads are allowable.

C. *Resource Roads.* These Bureau roads normally are spur roads that provide point access and connect to local or collector roads. They carry very low volume and accommodate only one or two types of use. Use restrictions are applied to prevent conflicts between users needing the road and users attracted to the road. The location and design of these roads are governed by environmental compatibility and minimizing Bureau costs, with minimal consideration for user cost, comfort, or travel time.

.17 **Average Daily Traffic (ADT).** For Bureau purposes, the average daily traffic (ADT) is defined as the annual traffic divided either by 365 or by the actual number of days the road is open to traffic. The amount of traffic is determined by the number of vehicles passing a point, regardless of direction of travel. ADT provides some criteria for geometric design standards and is used for justifications and in the design of structural elements. ADT is used as one of the factors in determining functional classification (see .16). Functional classification then determines the appropriate geometric standards (see .23).

.2 Road Standards. Standards are values established to insure adequate uniformity and quality of all roads constructed on lands administered by the Bureau. These standards are applied to all Bureau or non-Bureau initiated road construction, and are also used to determine the sufficiency of existing roads.

.23 Geometric Standards. Design speeds, travelway widths, and maximum grades for various combinations of estimated average daily traffic (ADT), functional classification (see .16.), and terrain types are shown at top of next page.

.24 Loadings. Design roads and structures for H-20 loadings, as specified by the American Association of State Highway and Transportation Officials. Designs with heavier loadings may be used if they are compatible with adjacent roads that could be affected by overweight traffic generated on Bureau-controlled roads.

.25 Structure Widths. Bridges, culverts, tunnels, cattle guards, and other structures must have a minimum curb-to-curb or rail-to-rail width (whichever is less) of 14 feet for single lane roads and 24 feet for double lane roads, but in all cases not less than the nominal width of the adjacent travelway as measured at right angles to the travelway centerline.

.26 Vertical Clearance. Overhead vertical clearance must be a minimum of 16 feet from the travelway elevation. (See .45E8.)

.27 Horizontal Clearance. A horizontal clearance of 4 feet from edge of roadway is recommended. (See .45E8.)

GEOMETRIC STANDARDS FOR BUREAU ROADS

FUNCTIONAL CLASSIFICATION	EST 20 YR. ADT	TERRAIN	DESIGN SPEED		TRAVELWAY WIDTH		MAXIMUM GRADE	
			PREF.	MIN.	PREF.	MIN.	PREF.	MAX.
Resource	Less than 20	LEVEL & ROLLING	30	*	14	*	8	10
		Mountainous	15	*	14	*	8	16
Local	Less than 100	Level & Rolling	40	30	20	20	6	10
		Mountainous	20	15	14	12	8	15
	More than 75	Level & Rolling	50	40	24	20	6	10
		Mountainons	30	15	24	20	8	14
Collector	50 - 150	Level & Rolling	50	30	24	20	6	8
		Mountainous	30	20	20	20	8	12
	More than 100	Level & Rolling	50	40	24	20	6	8
		Mountainous	30	20	24	20	8	12

NOTE: Design speeds and surface widths chosen are limited to values shown, except that greater widths are allowed when oversize traffic justifies wider widths. Maximum acceptable grade must never be exceeded and maximum preferred grade should be exceeded only when preferred value is not feasible.

*If preferred design speed and travelway width are not feasible for specific resource roads, alternate values are determined by the Chief, Branch of Engineering (State Office).

.28 Signs and Markers. Signs and markers placed on or adjacent to the roadway to regulate, inform, or guide vehicle occupants must conform to the requirements of BLM Manual Section 9131 and the Federal Highway Administrations Manual of Uniform Traffic Control Devices.

.29 Easement Widths. The width of easements for Bureau roads is limited to the minumum width necessary for construction and maintenance operations, and for user safety. A minimum width of 50 feet or the width of construction plus 10 feet on each side (whichever is greater) is generally required. Maintain uniform widths through varying ownerships or legal subdivisions whenever possible, rather than allowing frequent width changes.

.4 **Design.** Design work, whether "in-house," by another agency, or by an architectural and engineering firm, commences when project planning (route analysis and selection, environmental analysis, design narrative, and action plan) is complete and the project has been programmed and funded in an approved Annual Work Plan. Work on non-Bureau road designs should normally not begin until the preliminary location has been approved and the road stipulations have been provided to the applicant.

.42 **Designer Qualifications.** Any road designer assigned lead responsibility for the design of any road must have a working knowledge of highway engineering principles and procedures, and have satisfactorily completed a college or other Bureau approved road design course. The Chief, Branch of Engineering, State Office is responsible and accountable for the technical correctness of all road designs done "in-house" in his/her respective State, and determines designer qualifications. All "in-house" designs must receive an independent technical review by a qualified road designer. The Chief, Branch of Engineering, reviews and determines the procedures and organizational level for such reviews. Roads designed by non-Bureau personnel are approved for technical correctness by a qualified registered engineer or another agency's design chief, and are reviewed by the Chief, Branch of Engineering, State Office, or qualified District engineering personnel, to assure that the design meets the appropriate Bureau road standards.

.44 Surveys and Investigations. The type, accuracy requirements, and intensity of surveys and materials investigations is determined by the functional classification of the proposed road, land ownership, and the type of construction. Surveys and investigations supply data to the designer; therefore, the designer must work closely with the survey crew and soils/materials investigation crews to assure that the obtained data are pertinent. The designer directs the centerline survey and the location of soils/materials investigations by flagging on-the-ground locations or by plotting the proposed design alignment on large-scale topographic maps or aerial photos.

B. *Ground Surveys.* Ground surveys for road design are governed by the following guidelines:

2. *Precision of Surveys.* The accuracy requirements of road surveys as shown in Illustration 1 must meet the following precision classes:

a. *Collector Roads.* Traverses, level circuits, and cross-sections require precision class B.

b. *Local Roads.* Traverses not requiring easements are done to precision class C; easements require precision class B. Level circuits require precision class C, and cross sections require precision class D.

c. *Resource Roads.* Traverses not requiring easements are to precision class E; easements require precision class B. Level circuits require precision class E, and cross sections require precision class F.

3. *Stationing.* Stations are set continuously along centerline surveys at maximum 100-foot intervals, at all tangent and curve control points, at all fence or utility crossings, and at all breaks in ground profile where the centerline ground varies more than 1 foot vertically from a straight line connecting the above points. Stations should also be set along curves at a maximum of 100 feet or 4° of central arc, whichever is less.

4. *Topographic Survey.* Survey existing man-made features (buildings, fences, utilities, existing road, etc.) and natural features (rock outcrops, streams, swamps, lakes, trees, and cacti to be preserved, etc.) that require special design considerations or that may affect construction operations. Show these features on the construction drawings.

5. *Section Corner and Boundary Ties.* All road centerline traverse surveys must be tied to the Public Land survey system, using the same precision required for the traverse. Ties should be made each time the centerline traverse crosses a section line or boundary line (ownership, withdrawal, reservation, etc.). If all of the traverse is within one section, a tie should be made near each end of the centerline traverse.

6. *Establishing Bearings.* Astronomical observations are used to establish bearings on centerline traverses requiring easements. Establish bearings on other surveys by astronomical observation or by turning an angle from a known bearing, such as cadastral survey lines or other road survey centerlines. The basis of observed or calculated bearings is shown in the survey notes and on the construction drawings.

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7. *Bridges and Major Culverts.* See BLM Manual Section 9112.

8. *Survey Notes.* Surveys notes are kept in a bound book using the format required by the RDS handbook.

C. *Soil Surveys and Material Site Investigations.* Soils surveys and material site investigations furnish necessary information on the types of soils and physical limits of the various soils or materials that will be encountered on a project. The extent of survey and sampling and testing work required depends on the type and size of the project and the character of the soils.

1. *Soil Surveys.* A soil survey includes a soils profile made along the proposed centerline. Establish a trial profile grade line and conduct an investigation to determine the soil horizons and limits by examining exposed soils, and using auger borings or test holes at sufficiently close intervals and of sufficient depth to identify changes in soil types. Visual classification is sufficient for lower standard roads that will not carry heavy loadings. Roads being designed for heavy loads, high volumes, or paving require more thorough and accurate sampling and testing to determine structural values. Extensive testing is advisable for projects with large earthwork volumes. Use AASHTO classification, sampling, and testing procedures for road soil surveys.

2. *Materials Site Investigations.* Designated materials sites are sampled and tested to determine if the volume and character of the material is adequate and if the material can meet the required specifications. Use AASHTO sampling and testing procedures for material site investigations.

3. *Commercial Material Sources.* Manufactured aggregates, ready-mix concrete, and other materials may be available from commercial sources. Sampling and testing for design purposes is unneccessary if the supplier furnishes required information and certification.

.45 Design Guidelines. Design guidelines reflect the Bureau philosophy for road design. Bureau roads are designed and constructed primarily to support the protection, development, use, and administration of public lands and resources, while the primary purpose for most non-Bureau roads and highways is to move traffic rapidly and economically from point to point. Bureau roads must insure the safety of the user, but should respect the natural setting of the area. Designers of Bureau roads must be sensitive to national policy emphasizing safety, esthetics, protection and preservation of historic and cultural values, and accessability for the physically handicapped. Designers of Bureau roads must routinely incorporate these considerations in their designs.

A. *Design Speed.* Design speed determines the maximum degree of road curvature as well as minimum safe stopping, meeting, passing, or intersection sight distances. The design speed selected should be consistent with the anticipated speed users will drive on the constructed road. For example, in flat, open terrain where relatively straight alignment may induce drivers to travel relatively fast, low design speeds are unsafe.

1. *Maximum Degree of Curvature.* The maximum degree of curvature is determined by design speed, surface type, and the maximum superelevation rate. Using the maximum superelevation rate chosen by the designer, (see .45D) and the surface type of the proposed road, the maximum allowable curvature for various design speeds is determined using the rates shown in Illustration 2.

2. *Sight Distances.* Sight distances are those lengths of road the driver must be able to see to execute safely various vehicle operations. Sight distance requirements affect vertical curvature and may affect horizontal alignment by requiring easier curves to avoid sight obstructions due to terrain, vegetation, or man-made features. The designer may be required to adjust the horizontal or vertical curvature, the typical cross section, or to remove vegetation or man-made features to attain the required sight distances. Sight distance calculations are based on an eye height of 3.75 feet, and object height of 0.5 feet, and an opposing vehicle height of 4.50 feet. Driver perception and reaction time of 2.5 seconds is used. Since braking distance is related to surface type and weather conditions, it would be difficult to cover all forseeable combinations of situations on Illustration 3. Therefore, the tables on Illustration 3 shall be used as a guide requiring engineering judgment for conditions other than those indicated on the table. Friction factors for braking distance assume wet pavement conditions. Illustration 3 provides minimum safe stopping, meeting, passing, and intersection sight distance design values for Bureau roads.

B. *Horizontal Alignment.* Alignment for higher standard roads should be as direct as possible with few curves and more than minimum sight distances. Coordinate horizontal alignment with vertical alignment to insure user safety and comfort. Lower standard road designs should maintain a high quality alignment, but cost consideration may require that values normally required for higher standard road designs be lessened for construction economy. Accepted practices for good alignment design include the following:

1. *Terrain.* Fit the terrain.

2. *Curve Length.* Avoid short curves that provide the illusion of an angle. In open areas with long sight distances, the minimum curve length should be 500 feet for a 5 degree central angle. Where sight distance is limited, choose curves that appear to flow rather than curves that appear abrupt.

3. *Reverse Curves.* Avoid reverse curves separated by a short tangent. Where terrain dictates reverse curves, a tangent between curves of sufficient length to provide superelevation runoff without overlap is required.

4. *Broken Back Curves.* Broken back curves (two curves in same direction separated by a short tangent) should not be used. Substitute a longer curve or a compound curve.

5. *Curves on Fill.* If a curve must be placed on fill, keep it as flat as possible.

6. *Compound Curves.* Compound curves may be used to fit the alignment closer to the natural contour, or to avoid the use of broken back curves. Compound curves should be limited to three separate curves, with the center curve being the sharpest, but not over 50% sharper than adjacent curves.

7. *Tangents.* Long tangents, over one mile long, should be avoided, unless the road is a "section line" road.

8. *Alignment.* Consistent alignment is safer and is more esthetically pleasing. Sharp curves at the end of long tangents, or a sharp curve among easy curves is hazardous. Where a sharp curve must be used, it should be approached by successively sharper curves from both directions.

C. *Vertical Alignment.* Controls on vertical alignment include maximum grade requirements for the applicable road standard (see .23) and the vertical curve length requirements for minimum sight distances.

1. *Vertical Curves.* Vertical curves must be long enough to provide minimum stopping sight distance throughout the road length and to provide a road that is safe, comfortable, pleasing in appearance, and adequately drained. Vertical curves longer than required for minimum sight distance should be used to reduce earthwork volume or to provide a better visual appearance.

a. *Stopping Sight Distance (SSD).* Minimum stopping sight distance must be met for the entire length of all roads. Use Illustration 4 for determining the minimum vertical curve length for crest vertical curves, Ilustration 5 for determining minimum vertical curve length for sag vertical curves, and Illustration 6 for determining the minimum lateral clearance to the inside of horizontal curves.

b. *Passing Sight Distance (PSD).* Minimum passing sight distance should be met at regular intervals on two-lane roads. Higher volume roads require more frequent passing opportunities than lower volume roads. Construction costs are a major factor in determining passing sight distance needs.

c. *Meeting Sight Distance (MSD).* Minimum meeting sight distance must be met over the entire length of all single lane road sections. Meeting sight distance is calculated as the sum of the opposing stopping sight distances. Distance adjustment for grades may be ignored since such adjustments tend to cancel one another. Vertical curves provide safe stopping sight distances (See Illustration 7 for determining crest vertical curve lengths). However, safe meeting sight distance may require that lateral clearance on the inside of horizontal curves be lengthed, or that a double-lane section be used and the lateral clearance provide minimum stopping sight distance.

2. *Recommended Practices.* Recommended practices for providing a desirable vertical alignment are as follows:

a. Coordinate vertical alignment and horizontal alignment to insure a smooth flowing, safe, comfortable, and esthetically pleasing road.

b. Provide a "grass roots" grade requiring minimum earthwork. This limits costs, reduces erosion, and is more environmentally acceptable.

c. Provide a smooth vertical alignment with gradual changes consistent with class of road and character of terrain. Avoid an alignment with abrupt transitions.

d. Avoid grades less than 0.5 percent due to difficulty in providing drainage of side ditches.

e. Reduce grades around sharp curves, at intersections, at turnouts, and at turnarounds.

f. Avoid roller coaster, hidden-dip, and broken back grade lines, even though they may reduce earthwork quantities (not applicable for very low cost roads).

g. When possible, avoid locating a vertical curve within a horizontal curve.

D. *Superelevation of Curves.* The selection of a maximum superelevation rate should depend on several factors: frequency and amount of ice and snow; amount and type of roadside development; and number of slow moving vehicles. Illustration 2 provides recommended maximum superelevation rates for various design speeds. The minimum superelevation rate for any curve is not less than the normal crown rate for adjacent tangent sections. Superelevation is required on all roads with a design speed of 20 mph or greater. Bureau roads with design speeds of 20 mph or less do not require it. See Illustration 8 for runoff lengths for various superelevation rates and design speeds. One third of this runoff occurs on the curve and two thirds on the tangent. Increase runoff lengths where necessary to provide for better drainage or esthetics.

E. *Cross Section Elements.* The designer must determine the typical cross section(s). Changes in terrain, materials, visual resources, and vegetation may justify changing the typical cross section. Elements of the cross section include subgrade width, roadway crown or cross-slope, side ditches, cut and fill slopes, widenings, and turnouts.

1. *Subgrade Width.* The subgrade width normally is equal to the travelway width plus twice the taper width of surfacing materials. For an earthen road, the travelway width is equal to the subgrade width. Extra widening for shoulder area may be provided where estimated ADT is over 400, or where special considerations justify a shoulder area. The taper of the surfacing material on surfaced roads provides a 'usable' shoulder area if the tapered slope is 4:1 or flatter. The taper slope ratio should be approximately the same as the slope ratio selected for the flattest fills or side ditch inslope, but should never be steeper than 3:1. A taper slope ratio flatter than 4:1 may be provided if justified, but it should not be common practice. Select the total subgrade width to the nearest even 2 feet.

a. Considerations for designing the subgrade width include the following:

(1) Changes in subgrade soil support values may require a change of the surfacing thickness, resulting in a change in taper and subgrade width.

(2) Using curbs may affect subgrade width.

(3) In areas with steep side slopes, the typical section may be narrowed by reducing the side ditch or by forming the side ditch in the surfacing course. This may be done only if the surfacing material can be protected from saturation and if the ditch shape and dimensions are such that user safety is not compromised.

2. *Road Crown.* The road should be crowned to insure proper drainage. All double lane roads except insloped or outsloped roads must have a centerline or shoulderline crown. (See .45E3.) Place shoulderline crowns with the downstream shoulder highest in order to prevent erosion of fills. Recommended slopes are as follows:

Earth Surface	.03-.05 ft./ft.
Aggregate Surface	.02-.04 ft./ft.
Paved Surface	.02-.03 ft./ft.

3. *Insloped or Outsloped Roads.* A local road with a design speed of 20 mph or less may be insloped or outsloped for sections where the grade does not exceed 6%. (An insloped or outsloped road is a road without side ditches and superelevated curves.) Insloping or outsloping roads are not recommended unless the subgrade materials

are resistant to erosion and traffic volume is extremely low. The slope across the roadway is the same as for normal crowns. (See .45E2.).

4. *Cut and Fill Slopes.* Cut and fill slopes provide: a structurally stable road, a safe recovery area for errant vehicles, minimum erosion susceptibility, and maximum revegetation possibility. Slopes steeper than 2:1 in level and rolling terrain or 1 1/2:1 in mountainous terrain must not be used. If the steepest allowable slopes do not intersect with the natural terrain within a reasonable distance, make adjustments in the alignment and/or grade, or provide retaining walls. Fills with heights less than the depth of the side ditch are designed and staked as a cut section to insure continuity of the side ditch.

a. The following slopes are suggested for use on Bureau roads. Where rock excavation is encountered, cut slopes may be steeper since weathered slopes should remain stable. Cut slopes may be steeper than recommended to reduce resource, environmental, or visual impacts; however the angle of repose of the exposed material must not be exceeded.

RECOMMENDED EARTH SLOPES FOR BUREAU ROADS

Height of Cut or Fill (in Feet)	Level and Rolling Terrain	Mountainous Terrain
0-4	4:1	3:1
4-10	3:1	2:1
Over 10	2:1	1½:1[1]

[1]In clayey or silty soils subject to erosion, maximum slope should be limited to 2:1 or less, depending on stability of the soils.

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b. Fill widening a minimum of 2 feet is recommended where the slope is 2:1 or steeper. Fill widening must be intergrated with the normal embankment. Widening for curves and/or guardrails is determined independently of fill widening, and does not supersede fill widening requirements (see .45E9). Fill widening does not require widening of surfacing courses.

c. Slopes can be sculptured to provide a more natural appearance. Sculpturing is recommended for major roads through areas of high visual quality. Consult with visual management specialist on the advisability of slope sculpturing. Sculpturing methods include:

(1) Flattening slope at cut-to-fill transitions;

(2) Laying back cutslopes where a cut intersects a natural drainage to provide a more natural appearance;

(3) Accenting natural ridges intersected by cuts with a steeper cut slope and wider rounding of intersection;

(4) Creating diversity in long cuts by flattening slopes to create false draws;

(5) Providing benches in rock cuts to accent natural strata;

(6) Leaving planting pockets in rock slopes;

(7) Leaving unhazardous rock outcroppings to add variety; and

(8) Varying slopes to save specimen trees, rock outcrops, or other items of visual interest, provided they do not constitute a roadside hazard.

d. The intersection of cut and fill slopes with natural ground should be rounded to improve integration with the natural topography. Slopes are normally rounded for approximately 5 feet on each side of the intersection between the constructed slope and natural ground.

e. Slope treatments include revegetation and other landscaping techniques used to stabilize slopes and retard erosion. Use serrated slopes, topsoil, mulch, and jute matting if local conditions justify them. Revegetation with native grass and wildflower species is preferred. Other landscape treatments such as tree and shrub plantings or selected thinning of adjacent vegetation can mitigate the impact of the construction in areas of high visual quality. The degree of treatment is scaled to the location and purpose of the road. Landscape treatments should be coordinated with a landscape architect.

5. *Daylight Sections.* Daylighting of cuts is recommended if the disturbed slope area is not excessive. To daylight a slope, use a ratio of approximately 100:1 beginning at the bottom of the side ditch. (Note: The RDS program starts daylight sections at the shoulder point, so if RDS is used for Bureau road designs, consult the engineering computer application specialists at the Service Center to determine proper coding for designing daylight sections.

6. *Side Ditches.* Side Ditches (borrow ditches) are adjacent to and parallel with the roadway shoulder. They also collect the runoff from the roadway from adjacent upstream areas if no intercept ditch is provided above the cut slope. The shape and dimensions of the ditch are selected to carry adequately the anticipated runoff from a major storm without saturation of subgrade or surfacing material. As it must be safe for errant vehicles, the ditch is wider for higher design speeds and has an inslope (the slope between the subgrade shoulder and the ditch bottom) of the same ratio as the flattest fill slope. Flat bottom ditches are recommended for higher speed roads, and should have a 10 foot minimum bottom width (to facilitate normal construction equipment) and a bottom sloping slightly away from the travelway. A minimum longitudinal gradient of 0.5 percent insures good drainage. Vary ditch sections as required to satisfy differing conditions.

7. *Turnouts.* Turnouts are provided on single lane roads for opposing traffic. Turnouts normally are spaced at a maximum distance of 1000 feet. For higher volume or higher speed roads, a maximum distance of 700 feet is recommended. Locate turnouts so they are intervisible, where needed, and where most economical. On haul roads, try to locate turnouts on the right side of the "empty" direction. The most economical locations for turnouts are usually on the low side in cuts, high side in fills, or at the transition between cuts and fills. Recommended turnout dimensions are 100 feet long with 50 feet transitions, but these may be changed to fit terrain. Width should be 10 feet. Eight feet width may be sufficient for longer

turnouts. As vehicles generally come to a stop or are travelling at low speed at turnouts, the slope of the turnout may be less then the superelevation of the adjacent travelway on curve sections.

a. Turnouts can provide a second lane to satisfy safe meeting sight distance requirements around blind curves, however the design must still provide for safe stopping sight distance. The minimum width of turnouts should be at least 10 feet, with additional width recommended for roads serving overwidth vehicles. The cross slope of the turnout is the same as the adjacent travelway cross slope. Satisfying meeting sight distance requirements by providing lateral clearance or by flattening curves is preferable to using blind curve turnouts. Widening of the travelway with long turnouts encourages higher speeds and increases hazard.

b. Long turnouts are acceptable for double lane roads with high traffic volumes and a mix of fast and slow moving vehicles. They allow passing on uphill grades. Safe passing sight distance is not required if lane markings or signing prevent opposing traffic from entering the passing lane.

c. Turnarounds are provided as needed on single lane roads. Turnaround dimensions must be adequate to allow the average vehicle using the road to turn around with minimum maneuvering.

8. *Vertical and Horizontal Clearance.* A minimum vertical clearance of 16 feet must be provided. Clearances on already existing roads of

less than 14 feet must be properly signed. (See BLM Manual Section 9131). A minumum horizontal clearance of 4 feet from the edge of travelway is recommended. A runoff distance that is safe, negotiable by errant vehicles, and free of hazards located adjacent to the edge of the travelway is recommended. If safe runoff distances for roads with design speeds of 30 mph and above cannot be provided, seriously consider installing guardrails or other protective devices, particularly when the road is used by the general public.

9. *Curve and Guardrail Widening.* Widening of the sub-base and surfacing materials are recommended for curves with a radius of 400 feet or less, and for areas where guardrails are to be installed. Curve, guardrail, and fill widening (See .45E1.) requirements are independent of one another, but widening for any cause is integrated with normal subgrade and surfacing construction operations.

a. Curve widening is provided at the rate of W equals 400/R, where W equals the widening in feet rounded to the nearest foot, and R equals the radius of the curve in feet. Curve widening is generally placed on the inside of a curve, with the transition generally occuring at the same location as the superelevation transition.

b. A 2-foot widening of the sub-base, in addition to any necessary fill or curve widening is required wherever a guardrail is to be placed. Length of transition for guardrail widening is governed by visual acceptability.

F. *Earthwork Design.* BLM encourages balanced earthwork design. Waste or borrow is discouraged unless material characteristics require it. Adjust alignment, gradient, or slopes to eliminate need for waste or borrow, or utilize retaining walls, cribs, typical section adjustments, etc. to provide a balanced design. Side-cast waste is environmentally unacceptable. Any waste and borrow areas must be located out of view of the constructed roadway. Embankments should be constructed with the addition of suitable moisture to obtain density. Compact the top foot of subgrades of all roads that are to be surfaced or paved to a 95 percent maximum density as determined by AASHTO T-99.

G. *Aggregate Surfacing and Pavements.* (Reserved.)

H. *Drainage Elements.* Proper drainage is critical in road design. Protection of the road, adjacent upstream land, and downstream lands depend upon proper drainage design. This requires knowledge of both hydrology and hydraulics. When determining hydrology, the designer must also review land-use plans for upstream areas that could affect the amount of runoff during the life of the structure.

1. *Bridges and Major Culverts.* Design must conform to BLM Manual Section 9112. A major culvert is a culvert or multiple installation of culverts having an end area opening of 35 square feet or more. A bridge is a crossing structure erected over a depression, or obstruction having a track or passageway for carrying traffic or other moving loads.

2. *Drainage Culverts.* Culverts are used for all minor drainage crossings, unless debris problems or unusually low volume justify the use of a ford. The ford must be safe and environmentally compatible. Very low volume resource roads that are outsloped or insloped are usually the only type that may utilize fords.

a. Design culverts to pass a 10-year flood without development of static head at the entrance; balance the roadway grade and culvert size to avoid serious head and velocity damage for a 25-year flood. Decrease culvert capacity for shorter return storms or increase culvert capacity for longer return storms, as required by the functional importance of the road. Use any of the standard hydrologic and hydraulic design methods, but use a second method as a check to insure that the solution is adequate but not extravagant. Special consideration may be necessary for debris passage.

b. The type of culvert is specified in the design. If possible, specify alternate acceptable culvert materials.

c. An 18-inch diameter or equivalent size is the smallest culvert normally used. Smaller sizes are difficult to clean and maintain.

d. Minimum recommended cover over a culvert is 12 inches or one-half the diameter, whichever is greater.

e. Culverts carrying runoff from one side of the road to the other between natural drainages are spaced as shown in Illustration 9, unless local experience dictates otherwise.

f. The inlet and outlet treatments of culverts include drop inlets, downspouts, energy dissipators, flared ends, headwalls, rip-rap, paving, and beveled ends. Choose an end treatment that insures that the culvert is properly protected, erosion is retarded, and the protrusion of the culvert is not a hazard to errant vehicles.

g. Culverts in small drainages should generally be aligned with the natural channel and with a gradient that maintains the natural drainage velocity so sedimentation or erosion is not increased. Culverts used as laterals are skewed to form an entrance angle of 45 to 60 with the side ditch, and have a gradient equal to or slightly greater than the approach ditch gradient.

h. Culverts may be protected from debris by deflectors, racks, cribs, raisers, basins, spillways, or other controls. Incorporate debris protection as necessary.

i. Culverts must be designed for minimum impact on aquatic life. Open bottom shapes should be used if it is necessary to maintain the character of the streambed. If a closed bottom shape is used, install the culvert so the gradient does not exceed one-half percent, placing the invert at least 6 inches below the natural streambed, and filling the bottom with rock and gravel to simulate natural steambed characteristics. Any construction in fish bearing streams must be accomplished during the time of year when the least aquatic environmental impact will occur.

3. *Ditches and Channels.*

a. Intercept ditches are used to intercept and carry sheet runoff to natural drainages before it can reach the roadway. A gradient of about 0.5 percent is recommended. Design intercept ditches to intercept and concentrate sheet runoff so the ditch does not erode.

b. Natural channels must be avoided when possible. If channel changes must be made, maintain the natural stream depth, width, general flow conditions and characteristics as closely as possible. Use appropriate protective devices, such as gabions, deflectors, and plantings. Vegetation near banks can provide natural sediment filters, shade, and shadows. Vegetation on slopes adjacent to channels reduces erosion and provides a natural sediment filter.

4. *Fords and Dips.* Fords and dips may be used if they are not a hazard to traffic. Design fords and dips to provide safe stopping sight distance. The roadway must be stable and self cleaning. Place signs and flow depth markers to protect users. Design dip-culvert combinations to insure that the stream gradient does not cause erosion or sedimentation; provide slope protection. Dip-culverts are to be considered as bridges or major culverts for design purposes and must comply with BLM Manual Section 9112.

5. *Subsurface Drainage.* Subsurface drainage is required to prevent failures due to excess moisture in the subgrade or subbase. Intercept or drain water with subdrains if necessary. Prevent runoff from saturating the subgrade or subbase material by providing proper drainage.

I. *Cattle Guard.* Cattle guards are placed normal to the roadway centerline on the finished roadway grade. If the road will be surfaced in the future, place the cattleguard at the final design elevation, with a 50-feet temporary ramp on each side to provide a smooth crossing. Use Bureau standard designs for all cattle guards. Cattle guard widths must meet requirements of BLM Manual Section 9113.25.

J. *Signs and Markers.* Each road design must include provisions for traffic control signing. Signs and markers must be in place prior to opening the road to traffic. These must meet the requirements of BLM Manual Section 9131. Roads open to traffic during construction must be signed in accordance with the Federal Highway Administration's *Manual on Uniform Traffic Control Devices.*

.47 **Permits.** Permits may be required whenever a Bureau road intersects with a Federal-aid, county, or municipal highway. Section 404 permits may be required for stream crossings or construction in streambeds (see BLM Manual Section 9112). Determine permit requirements and secure any needed permits in a timely manner in order to prevent construction delays. Permits that contain provisions affecting construction methods or schedules must be addressed in the plans and specifications.

.5 Construction.

.51 **Staking.** Construction stakes are placed as precisely as required for the design survey. (See .44B2.)

.52 **Signing.** Roads under construction are required to be signed according to the current edition of the FHWA's *Manual of Uniform Traffic Control Devices.*

.53 **Inspections.** Construction inspection must be done by qualified inspectors (see BLM Manual Section 9103). Use FHWA's *Construction Manual for Use with FHWA Standard Specifications* for inspection guidance if FHWA specifications are used for construction.

9113 - ROADS

Precision Requirements for Road Surveys

PRECISION REQUIREMENTS FOR ROAD SURVEYS

ITEMS	A	B	C	D	E	F
TRAVERSES						
Minimum linear closure	1/5000	1/3000	1/1000	1/600	1/300	1/100
Distance accuracy	1/7500	1/4500	1/1500	1/900	1/450	1/150
Angular accuracy (use least value)	1/7500. 30 sec. x $\sqrt{N}$[1] or 8.0 sec. per station. 2 sets, direct and reverse. 20 sec. rejection limit.	1/4500. 1 min. x $\sqrt{N}$[1] or 15 sec. per station. 1 set, direct and reverse. 1 min. rejection limit.	1/500. 90 sec. x $\sqrt{N}$[1] or 20 sec. per station.	1/900. If forward and backward bearings of tangents differ by more than 30 min. bearings must be computed as deflection angle traverse.	1/450. If forward and backward bearings of tangents differ by more than 1 deg., bearings must be computed as deflection angle traverse.	1/150
LEVEL CIRCUITS						
Vertical error of closure on bench mark (use least value)	0.05 $\sqrt{M}$[2] or 0.0015 foot per station in level circuit	0.1 $\sqrt{M}$[2] or 0.0025 foot per station in level circuit.	0.25 $\sqrt{M}$[2] or 0.005 foot per station in level circuit.	1.0 $\sqrt{M}$[2] or 0.02 foot per station in level circuit.	2.0 $\sqrt{M}$[2] or 0.04 foot per station in level circuit.	4.0 $\sqrt{M}$[2] or 0.1 foot per station in level circuit.
CROSS SECTIONS						
Allowable deviation of line projection from a true perpendicular to tangents and a true bisector of angle points	± 2°	± 2°	± 3°	± 3°	± 4°	± 4°
Topography measurements must be taken so that variations in ground from a straight line connecting the cross section points will not exceed	1.5'	1.5'	2.0'	2.0'	2.5'	3.0'
Horizontal and vertical accuracy, in feet, or percentage of horizontal distance measured from traverse line, whichever is greater.	0.1' or 0.5%	0.1' or 0.5%	0.2' or 1.0%	0.2' or 1.5%	0.3' or 2.0%	0.4' or 3.0%
SLOPE STAKES, REFERENCES, AND CLEARING LIMIT STAKES						
Horizontal and vertical accuracy, in feet, or percentage of horizontal distance measured from centerline or reference stake whichever is greater.						
a. Slope reference stakes and slope stakes.	0.1'	0.1' or 0.5%	0.2' or 1.0%	0.2' or 1.5%	0.2' or 1.5%	0.3' or 2.0%
b. Clearing limits	1.0'	1.0'	1.0'	1.5'	1.5'	2.0'

Maximum Curvature and Recommended Superelevation Rates

MAXIMUM DEGREE OF CURVE (MINIMUM RADIUS) FOR VARIOUS SURFACE TYPES, DESIGN SPEEDS AND MAXIMUM SUPERELEVATION RATES

SURFACE TYPE	DESIGN SPEED (MPH)	SIDE-FRICTION FACTOR	MAXIMUM SUPERELEVATION RATE (%)				
			.02	.04	.06	.08	.10
PAVED	10	.16	115° (50')	115° (50')	115° (50')		
	15	.16	73° (79')	77° (74')	81° (71')		
	20	.16	38° (150')	44° (130')	48° (120')		
	30	.16		18° (320')	21° (270')	23° (250')	
	40	.15		10° (500')	11° (510')	12° (480')	13° (430')
	50	.14		6° (930')	7° (830')	8° (760')	8° (690')
UNPAVED	10	.12	115° (50')	115° (50')	115° (50')		
	15	.12	52° (110')	61° (94')	70° (82')		
	20	.10	26° (220')	30° (190')	34° (165')		
	30	.09		12° (460')	14° (385')	15° (350')	
	40	.09		7° (820')	8° (720')	9° (630')	10° (560')
	50	.08		4° (1400')	5° (1200')	6° (1000')	6° (930')

NOTE: Values have been rounded to nearest even degrees and to two significant figures for radii

Minimum Sight Distances

WET PAVEMENT
MINIMUM STOPPING SIGHT DISTANCES

DESIGN SPEED (MPH)	ROAD GRADE (IN %)				
	+16 to +10	+10 to +3	+3 to -3	-3 to -10	-10 to -16
10	45	50	50	50	55
15	75	75	80	85	90
20	115	120	125	135	150
30	180	190	200	225	240
40	235	260	275	325	375
50		320	350	450	

WET PAVEMENT
MINIMUM INTERSECTION SIGHT DISTANCE

DESIGN SPEED (MPH) OF MAJOR ROAD	MINIMUM INTERSECTION SIGHT DISTANCE
10	100′
15	150′
20	200′
30	300′
40	400′
50	500′

Minimum Sight Distances

MINIMUM PASSING SIGHT DISTANCE

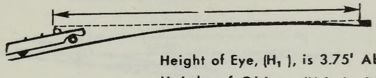
DESIGN SPEED (MPH)	10	15	20	30	40	50
MINIMUM PASSING SIGHT DISTANCE	500′	700′	850′	1100′	1500′	1800′

MINIMUM MEETING SIGHT DISTANCE

DESIGN SPEED (MPH)	10	15	20	30
MINIMUM MEETING SIGHT DISTANCE	100′	160′	250′	400′

Crest Vertical Curves Based on Minimum Stopping Sight Distance

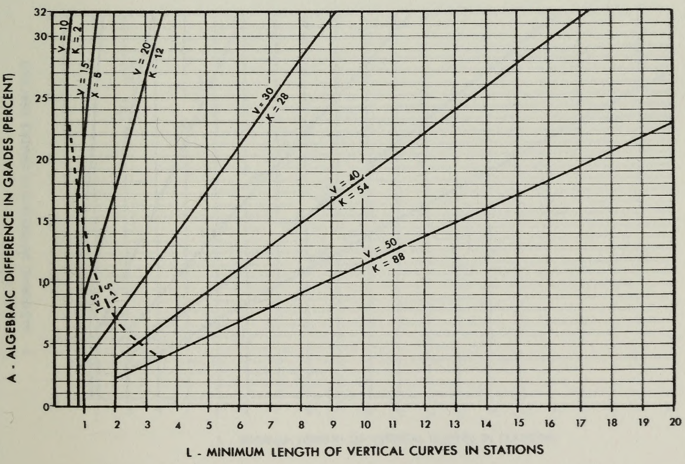
CREST VERTICAL CURVES BASED ON MINIMUM STOPPING SIGHT DISTANCE



Height of Eye, (H_1), is 3.75' Above Roadway

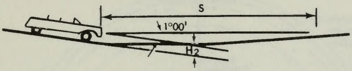
Height of Object, (H_2), is 0.50' Above Roadway

L=LENGTH OF VERTICAL CURVE IN FEET A=ALGEBRAIC DIFFERENCE IN GRADE(%) S=SIGHT DISTANCE IN FEET	DESIGN SPEED M.P.H. (V)	MINIMUM SIGHT DISTANCE, (S) REQUIRED, IN FEET	K=RATE OF VERTICAL CURVATURE, LENGTH PER PERCENT OF A	MINIMUM LENGTH OF VERTICAL CURVE WHEN S>L
$L = \frac{AS^2}{200(\sqrt{H_1}+\sqrt{H_2})^2}$ WHEN S<L	10	50	2	50
	15	80	5	80
$S = 37.4\sqrt{L/A}$	20		12	100
$K = \frac{L}{A}$ or $L = KA$ Rounded for Design	30	200	28	100
	40	275	54	200
	50	350	88	200



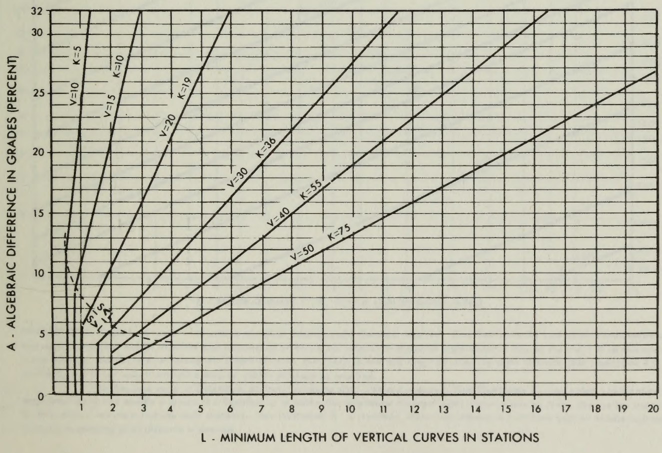
Sag Vertical Curves Based on Minimum Stopping Sight Distance

SAG VERTICAL CURVES BASED ON MINIMUM STOPPING SIGHT DISTANCE



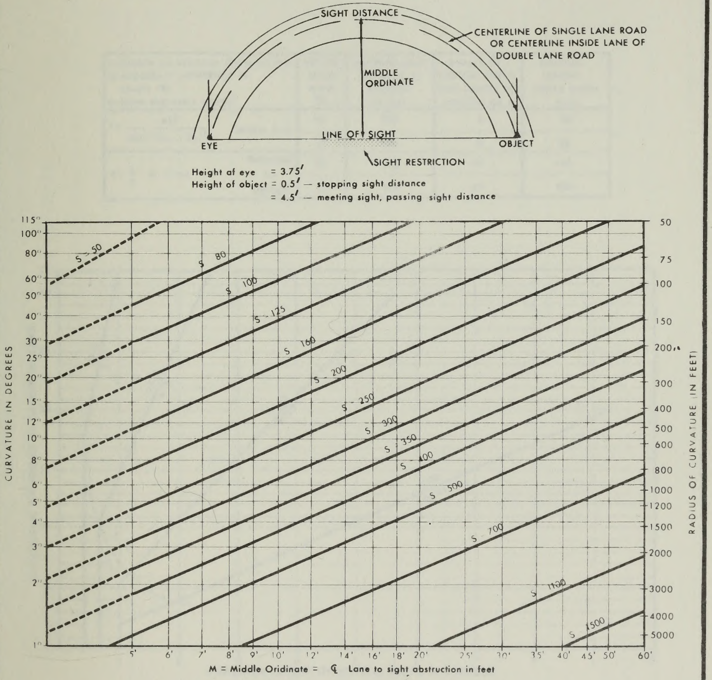
HEIGHT OF HEADLAMP ABOVE ROADWAY (H_2), IS 2.00 FEET

L=LENGTH OF VERTICAL CURVE IN FEET A=ALGEBRAIC DIFFERENCE IN GRADE(%) S=SIGHT DISTANCE IN FEET	DESIGN SPEED M.P.H. (V)	MINIMUM SIGHT DISTANCE (S) REQUIRED, IN FEET	K=RATE OF VERTICAL CURVATURE LENGTH PER PERCENT OF A	MINIMUM LENGTH OF VERTICAL CURVE WHEN S>L
$L = \frac{AS^2}{200 H_2 + 3.5S}$ When S<L	10	50	5	50
	15	80	10	80
	20	125	19	100
$K = \frac{L}{A}$ OR $L = KA$ Rounded for Design	30	200	36	150
	40	275	55	200
	50	350	75	200



Sight Distance Provided by Lateral Clearance and Curve Combinations

SIGHT DISTANCES PROVIDED BY VARIABLE LATERAL CLEARANCE AND CURVE COMBINATIONS



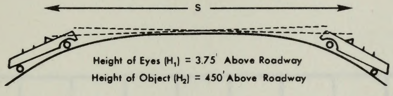
INSTRUCTIONS: Single lane road — determine minimum meeting sight distance required (See illustration 3) and select combination of horizontal curve and middle ordinate that intersect at or below the respective diagonal sight distance line on the chart. If combination is not feasible, provide turnout throughout length of curve and check to see that required stopping sight distance (See illustration 3) is provided, and if not, adjust curvature and/or middle ordinate as required.

Double lane road — Determine minimum stopping sight distance required (See illustration 3) and select combination of horizontal curve and middle ordinate that intersect at or below the respective diagonal sight distance line on chart. Use similar method to determine if minimum passing sight distance (See illustration 3) is provided. Make adjustments in curvature and/or middle ordinate if minimum passing sight distance is desired.

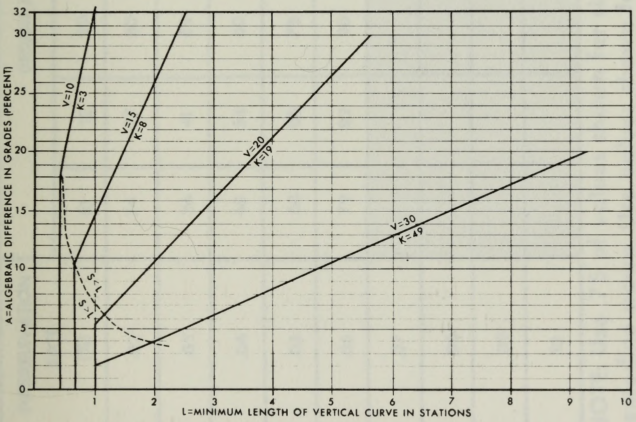
Crest Vertical Curves Based on Minimum Meeting Sight Distance

CREST VERTICAL CURVES BASED ON MINIMUM MEETING SIGHT DISTANCE

(Single Lane Roads Only)



L=LENGTH OF VERTICAL CURVE IN FEET A=ALGEBRAIC DIFFERENCE IN GRADE (%) S=SIGHT DISTANCE IN FEET	DESIGN SPEED M.P.H. (V)	MINIMUM SIGHT DISTANCE, (S) REQUIRED, IN FEET	K=RATE OF VERTICAL CURVATURE LENGTH PER PERCENT OF A	MINIMUM LENGTH CURVE WHEN S>L
$L=\frac{AS^2}{200(\sqrt{H_1}+\sqrt{H_2})^2}$ WHEN S<L	10	100	3	50
	15	160	8	80
$K=\frac{L}{A}$ or L=KA Rounded for Design	20	250	19	100
	30	400	49	100



Minimum Superelevation Runoff Lengths

MINIMUM SUPERELEVATION RUNOFF LENGTHS

SUPERELEVATION RATE (%)	DESIGN SPEED (MPH)					
	10	15	20	30	40	50
.02	24	27	30	36	42	48
.03	36	41	45	54	63	72
.04	48	54	60	72	84	96
.05	60	68	75	90	105	120
.06	72	82	90	108	126	144
.07				126	147	168
.08				144	168	192
.09				162	189	216
.10				180	210	240

NOTE: Use .75 of values shown for single lane roads with centerline crown. Use values shown for double lane roads and shoulder crowned single lane roads.

Spacing for Drainage Laterals

Recommended Spacing for Lateral Drainage Culverts
in Various Soil Types*

Soil Types	Erosion Index 10	20	30	40	50	60	70	80	90	100
Silty sands, sand-silt mixtures, inorganic silts and very fine sands, silty or clayey fine sands	X	X								
Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, organic silts and organic silty clays or low plasticity, inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			X	X						
Organic clays of medium to high plasticity, organic silts, inorganic clays of high plasticity, fat clays, clayey sands, sand-clay mixtures, silty-gravels, gravel-sand-silt mixtures					X	X				
Clayey gravels gravel-sand-clay mixtures							X			
Clean sands or clean gravelly sands								X	X	
Clean gravels or sand-gravel mixtures										X

* Unified Soil Classification

Gradient in percent	Recommend Spacing in Feet — Erosion Index 10	20	30	40	50	60	70	80	90	100
2	900	1225								
3	600	815	1070	1205						
4	450	610	800	905	1015					
5	360	490	640	725	810	865	1000			
6	300	410	535	605	675	720	835	1010		
7	255	350	455	515	580	620	715	865	1030	1210
8	225	305	400	450	505	540	625	755	900	1055
9	200	270	355	400	450	480	555	670	800	940
10	180	245	320	360	405	435	500	605	720	845
11	165	220	290	330	370	395	455	550	655	770
12	150	205	265	305	340	360	415	505	600	705
13	140	190	245	280	310	335	385	465	555	650
14	130	175	230	260	290	310	355	430	515	605
15	120	165	215	240	270	300	335	405	480	565
16	115	155	200	225	255	280	310	380	450	530

This table is based on rainfall intensities of 1 to 2 inches per hour following in a 15 minute period with an expected interval of recurrence of 25 years. For areas having intensities other than 1 to 2 inches per hour, divide values in the table as follows:

Rainfall Intensity	Divisor
2 - 3 inches per hour	1.50
3 - 4 " " "	1.75
4 - 5 " " "	2.00
Less than 1 inch per hour	Whatever the intensity (.75, .85, etc.)

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